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Improved Water Supply in the Ghanaian Volta Basin:Who Uses it and Who Participates in Community Decision-Making?

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ABSTRACT

We examine access to, use of, and participation in decisions on improved water supply in the Volta basin of Ghana, one of the first countries to introduce a community-based approach to rural water supply on a large scale. While 71 percent of the households interviewed have access to improved water, 43 percent of these continue to use unsafe sources as their main domestic water source. Our results indicate that quality perceptions and opportunity costs play an important role in households' choice of water source. The effect of prices and income levels on this choice differs according to the pricing system used. Given that supply characteristics such as the location and pricing system affect household decisions to use the improved source, households may try to influence these characteristics in their favor during the community decision-making process for the improved source. However, less than 40 percent of the households interviewed participated in decisions on location or technology. We argue that the decision whether to participate depends on three main factors: (i) the household's bargaining power, (ii) the potential benefits from influencing outcomes, and (iii) the cost of participation, (mainly opportunity cost of time). Our results indicate that bargaining power matters more than potential benefits. Moreover, we find an *extremes effect:* the poorest, uneducated and the richest, highly educated segments of the community are more likely to participate in decision-making for improved domestic water supply than the middle class. We conclude with policy implications and needs for further research.

Keywords: water safety, water use, participation, community-based resource management

CONTENTS

Improved Water Supply in the Ghanaian Volta Basin: Who Uses it and Who Participates in Community Decision-Making?[1]

Stefanie Engel, Maria Iskandarani, and Maria del Pilar Useche[2]

1. INTRODUCTION

One of the goals of the international community stated in the United Nations Millennium Declaration is to reduce by half the population with no access to safe water by 2015. According to WHO/UNICEF (2000) 1.1 billion people lack access to improved water supply.[3] Due to population growth and rapid urbanization this number will likely rise rapidly in the coming years unless serious measures are undertaken to stem the tide. Massive investments in supply infrastructure are required as well as reforms in the operation and maintenance of supply systems to increase efficiency. In the past, water supply was typically planned and operated by the central government or a national authority. Budget constraints, low revenues, and shortfalls in operation and maintenance have resulted in insufficient expansion of the system and gradual degradation of service at the same time that water demands increased and scarcity worsened. This development has led to the recognition that water should no longer be seen as a public good only, but also as an economic good. It is now widely accepted that households should pay for improved water, and revenues should cover at least the operation and maintenance cost. Furthermore, a withdrawal of the central government from supplying water and operating the system, and the introduction of public-private partnerships in water supply have been shown to help relieve budget constraints

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[3] Along with the WHO/UNICEF (2000) definition the following technologies are considered "improved": household connection, public standpipe, borehole, protected dug well, protected spring, and rainwater collection. As "not improved" are considered: unprotected well, unprotected spring, vendor-provided water, bottled water (because of limitations concerning the potential quantity of supplied water, not the quality) and tanker truck provision of water.

and improve supply efficiency, if implemented appropriately. For rural areas, community management of water resources under government guidance has been advocated (Brookshire et al. 1993; Atlaf et al. 1993; Munasinghe 1992).

This paper addresses these issues in the context of rural water supply in the Volta River Basin in Ghana, which introduced community water management in rural areas in the early 1990s (Asante et al. 2002). The assessment is based on data collected through household and community surveys in the Ghanaian Volta basin.[4] The paper examines access to improved water sources in rural communities in the basin as well as the factors that determine households' decisions in using a specific water source. Access to improved water does not automatically translate into use by all households. Particularly in rural areas, improved water facilities are often underutilized or abandoned while households choose to continue the use of traditional water sources (Mu et al. 1990). The decision to use a particular water source is influenced by prices and income constraints as well as preferences, knowledge, and perceptions about water quality differences. The effect of different pricing systems, the role of awareness about water quality, and the potential of exclusion of poor households from using improved sources where water is distributed at a cost are some of the policy-relevant issues addressed in this paper.

Moreover, the participatory approach to water supply adopted in Ghana and elsewhere implies that some of the factors that can explain differences in use—particularly supply characteristics like price, location, technology, and type of payment—are themselves subject to the influence of community members. This leads to further research questions, including: To what degree do rural households participate in decision-making about improved water supply? And why do some households participate—thereby potentially influencing outcomes in their favor—while others do not? These issues are analyzed for decisions regarding the location and

[4] A survey was conducted in 20 communities across the Volta River Basin in Ghana in 2001. In each community, approximately 25 households as well as a community representative were interviewed.

technology of the improved source. Linkages between the decision to participate and the choice of water source are examined explicitly.

One of the interesting issues arising in this context is how participation differs across segments of the community, grouped by income or education, for example. Are the poor likely to be excluded, as reflected in unfavorable locations and technologies, making it less likely for them to use improved water sources? Contrary to the *middle-class effect* that has been observed elsewhere (Weinberger and Juetting 2002), we find what we call an *extremes effect.* That is, the poorer and less educated as well as the richer and highly educated segments of the community appear more likely to participate in decision-making processes for water supply than the middle class.

The paper is structured as follows. Section two presents a brief review of the literature on determinants of household water use. This is followed by an introduction to the geographical and socioeconomic setting of the Volta River Basin in Ghana and a description of the reform process for rural water supply. The next section describes household water security in terms of access, usage, and consumption of water. The determinants of households' decisions to use improved water sources are estimated and household participation in decisions regarding improved water supply as well as potential explanatory factors for differences in participation across households and communities are examined in the sixth section. The last section concludes and presents policy implications.

2. FACTORS DETERMINING DOMESTIC WATER USE

Many of the water projects implemented over the last three decades in developing countries are considered failures (World Bank 1992). Experts from a variety of disciplines have examined factors determining success. They identified knowledge of the health benefits of improved water supplies, affordability of tariffs, sensitivity by donors and the central government to local customs and beliefs, the ability to operate and maintain water systems by the local population, as well as community participation and local involvement in design and management as important factors for rural people to use improved water sources (Brookshire et al. 1993).

Regarding the supply side, economic studies have emphasized the importance of improving project identification, design and construction, of understanding the institutions providing water and their tendency towards selecting capital-intensive enterprises and neglecting maintenance schemes, and of establishing strategic links between the water investment sector and other macroeconomic policies (Howe and Dixon 1993; Rogers et al. 1993).

On the demand side, the economic literature focuses on the valuation by households of different water sources and the analysis of determinants of water demand. Several studies conducted in developing countries over the past ten years have tried to evaluate the willingness to pay (WTP) for improved water supply by applying the contingent valuation approach (Whittington et al. 1990, 1991; Atlaf et al 1993, 1994; Briscoe et al. 1990; World Bank Water Demand Research Team 1993). The empirical results of all these studies show that the willingness to pay for improved water service does not depend solely on income, but equally on the characteristics of both the existing and the improved supplies. Income is often not the main factor determining water demand. The share of income that a household is willing to pay for water can vary widely – from 0.5% to 10%. Moreover, income elasticities of demand for access to improved water services have been estimated to be very low, for example, 0.15 in Brazil, 0.14 in India, 0.07 in Zimbabwe (World Bank Water Demand Research Team 1993). Furthermore, empirical analysis showed that more educated households are willing to pay more for improved water supplies; and that gender was a statistically significant determinant in WTP for improved water supply. However, the direction of the relationship between gender and WTP depends on the specific cultural context.

A second group of factors influencing demand for improved water supply relate to the characteristics of the existing water source versus those of the improved supply, including the cost (both financial and opportunity cost of time for collecting water), the quality, and the reliability of supply. A third set of characteristics influencing households' WTP relates to their attitude towards government water supply policy and their sense of entitlement to government service (World Bank Water Demand Research Team 1993). A more recent study looked at household water demand for improved piped water services in Kathmandu, Nepal (Whittington et.al. 2002). Here respondents were asked how they would vote given the choice between their existing water supply situation and an improved water service provided by a private operator. The study showed that households' willingness to pay for improved water services was much higher than existing water bills.

Using a discrete choice model of household water source decisions, Mu et al. (1990) emphasize the heterogeneous good characteristics of water in less developed countries. They argue that unavailability and bad quality of data, as well as the lack of variation in prices in many developing countries are a major constraint to using the price-quantity approach. The authors therefore limit their analysis to the type of water source households choose, instead of considering the simultaneous choice of quantity and source. The underlying assumption is that a household chooses the source independently of the amount of water used. Merret (2002) criticizes the previous methodologies because they do not take into account the multiple uses of water and their relationship to multiple sourcing. He suggests that behavioral studies into the domestic demand for water and wastewater services in low-income countries should be based on semi-structured interviews and incorporate the scale and composition of use and reuse and their relation to the quality of water. Madanat and Humplick (1993) actually implement an approach that takes Merret's suggested direction, considering the conditional demand for water by households according to each specific use within a multiple-stage-analysis framework, assuming that households only use one source for each specific use. This assumption is problematic, however. In the household survey for Ghana, for example, the majority of households use several sources for one activity, and water from one source is typically used for several activities.

Asante et al. (2002) analyze the access to different types of drinking water sources and the choice among sources for households in the Volta Basin in Ghana. They also provide an analysis of water-related diseases and relate migration to water access in the region. Their study finds that between 25-75 percent of households in the region use improved water sources. They also find a higher probability of out-migration in communities with scarce, low-quality drinking water sources and that education and household income are explanatory factors for households using improved water sources. However, due to lack of data, their analysis does not consider costs incurred by households using improved water sources, a possible omitted variable bias in their analysis.

The majority of the above mentioned studies do not consider the fact that households facing different pricing systems are subject to different decision processes. Merret (2002), for example, notes about the maximum willingness-to-pay approach that "…it lacks any clear meaning for a respondent who faces a volumetric pricing tariff for the scenario project. [The maximum willingness to pay]… can have a practical significance only when it applies, for example, to a monthly fixed charge for access to a water supply. [...] the results should be represented as that fixed charge and not as a unit price, for the only sense attributable to the latter in this case is the statistical ratio of the fixed charge to the unknown volume of water used, a ratio the user never computes." Related to this is the fact that the pricing system has an important impact on decision-making and on water use choices. For example, a price charged per unit of water consumed implies a marginal price of water that is positive, while a flat rate charged once per season or year implies a marginal price of zero and can be considered more like an investment decision. Our study will consider these issues by explicitly comparing determinants of the choice of water source for different pricing systems.

Thus, the literature highlights the nature of the financing process and considers consumers' welfare improvement as a function of their valuation of improved water only. The problem of embeddedness of economic action and social structure (Granovetter 1985) is not addressed. Structures of social relations determine who participates in a project and how the benefits of the project are distributed. Community management of improved water resources is based on the assumption that citizen involvement in planning decisions will foster both efficiency and equity. Lovei and Whittington (1993) point out that community participation in decisions and local control of water utilities is desired, in order to avoid rent-extracting behavior of agents that are able to gain control of water sources, restrict supply to users, and raise the water price. Njoh (2002) underscores the importance of a participatory approach in water projects to avoid problems such as a paternalistic posture of authorities, a prescriptive role of the state, selective participation, intra/inter-group conflicts, gate-keeping by leaders, excessive pressures for immediate results, and implementation problems because of lack of knowledge about belief systems. Rigorous analysis of who in the community actually participates in such projects is, however, missing. Weinberger and Juetting (2002) provide a theoretical framework to identify the determinants of participation. Their empirical analysis of two field sites in Chad and Kashmir suggests a "middle-class effect" in terms of income characteristics and a positive effect of membership in other informal groups, but renders inconclusive outcomes for the effect of bargaining power of individuals.[5] However, their “middle-class effect” analysis, based on two separate regressions, needs further study. In our analysis below we test for the middle-class effect in a single regression. Furthermore, we directly link the participation decision to the water use decision.

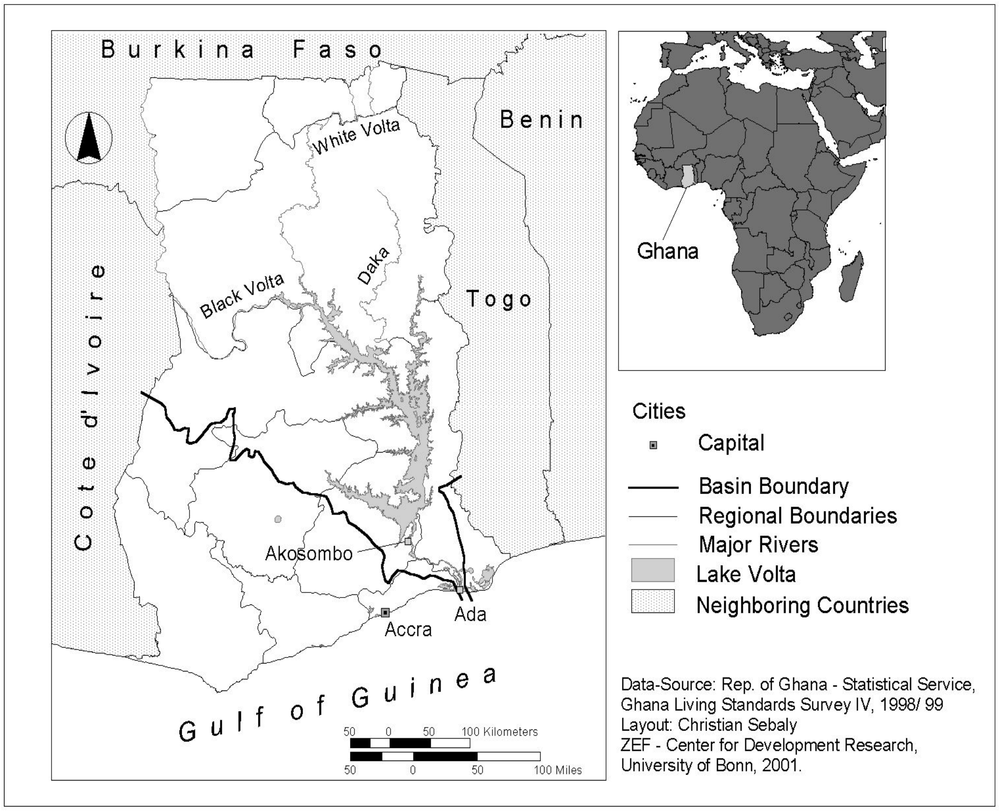
3. GEOGRAPHIC, ECONOMIC, AND INSTITUTIONAL SETTING OF THE STUDY SITE

THE VOLTA BASIN

The Volta basin covers an area of about 400,000 km² and connects six riparian countries—Ghana, Burkina Faso, and Togo and small parts of Côte d’Ivoire, Benin and Mali. The basin is of particular importance for Ghana as it drains about three quarters of the country through its main tributaries, the Black Volta, the White Volta, the Oti and the Lower Volta with the latter referring to the river downstream of the confluence of the Black and the White Volta (Andreini et al. 2000, see also Map 1). A major characteristic of the basin is the high rainfall variability in the upland areas with frequent droughts and seasonal water shortages and thus problems of water security. In 1964 the Akosombo Dam was constructed at the Lower Volta, creating one of the world’s largest reservoirs with a storage capacity of 148 km³ - commonly known as the *Volta Lake*. The hydropower produced is mainly used by the Volta Aluminum Company (Valco) and for the electrification of the country (Andreini et al. 2000). So far irrigation does not play a significant role in water use within the basin. However, a substantial increase in irrigation development in the Bukinabe and Ghanaian part of the basin is anticipated (Edig, Engel and Laube 2002).

[5] Possible correlation of several wealth measures, as well as endogeneity of the social capital variable could represent a problem for the reliability of their estimates.

Map 1--Ghana and the Volta Basin



Source: Asante et al. (2002)

ECONOMY AND POVERTY

Ghana has a population of about 18.9 million people (Ghana Statistical Service 2002), with about 10.2 million in the basin. The country's population growth rate is about 2.5 percent per year. However, growth varies significantly by region due to differences in fertility and migration. In the Upper Eastern and Upper Western Region population growth has declined significantly (from ~2.5 to ~1.4 percent per year between 1984 and 2000), whereas more urban areas like Greater Accra experience rapid population increase, more than 4 percent annually (3.3 in 1984), revealing a concentration in the peri-urban and urban areas in southern Ghana (Ghana

Statistical Service 2000a). However, the greater part of Ghana's population lives in rural areas (about 56 percent in 2000).[6]

In 2001, agriculture accounted for about 39.6 percent of total GDP, and the industrial and service sectors, for 27.4 percent and 33 percent, respectively (ISSER 2003). Electricity and water account for 2.8 percent (in 2001) of industrial GDP (ISSER 2003). Per capita GNP in 2001 was US$390.

Poverty alleviation is one of the major challenges in Ghana and particularly in the Volta basin. According to the Ghana Living Standard Measurement survey of 1998-1999 the percentage of people below the upper poverty line declined by 12 percent over the previous 7 years to 40 percent.[7] The decline in poverty is concentrated in Accra and forested localities in the southwest of Ghana – both located outside the basin. In most of the remaining areas, both urban and rural, poverty fell only very modestly, and in the urban and rural Savannah (which covers the main part of the basin) the proportion of the population defined as poor increased during the period. The incidence of extreme poverty—defined as households whose standard of living is insufficient to meet their basic nutritional needs even if they devoted their entire consumption budget to food—is more than 25 (26.8) percent in Ghana. The Savannah zone has the largest share of rural population living in extreme poverty, about 59 percent in 1998/99 (Ghana Statistical Service 2000b).

[6] A rural area is defined to have a population of less than 5000 inhabitants.

[7] Poverty has various dimensions: consumption poverty, lack of access to services and limited human development. Here, the poverty line is defined on a consumption requirement basis. It is differentiated between a lower poverty line ("extreme poverty") of 700,000 Cedis per adult and year (~US$262)—based on what is needed, to meet the nutritional requirements of household members—and the upper poverty line which is fixed at 900,000 Cedis per adult and year (~ US$337) and incorporates both essential food and non- food consumption. The statistics given here refer to the upper poverty line.

WATER (IN)SECURITY

Vulnerability to household water insecurity is a widespread problem in the basin, and water insecurity is closely linked to poverty. Water insecurity is based on inadequate water access and usage, particularly in the dry season when some of the water sources, e.g. wells, dry up. In addition to quantity, water of sufficient quality is an essential element for human development and poverty reduction, and a precondition for effective primary health care. In the Volta Basin a close relation between water and health can be observed. Major water-related diseases are malaria, diarrhea, schistosomiasis or billharzia, and guinea worm. They are endemic in most parts, and children are most vulnerable to these diseases. In terms of outpatient clinic attendance, malaria and diarrhea are the most frequent diseases. Malaria is also the major cause of mortality, especially among children.

Lack of access to safe drinking water is significant in the basin region, even if sufficient resources are available. A large share of the basin population relies on unimproved or unreliable water sources such as unprotected shallow wells, vendors, ponds, lakes, and rivers. These sources not only pose significant health risks, but are also costly to reach. Time and energy spent for fetching water could be used more efficiently, for example, for subsistence agriculture or schooling. In addition to the opportunity cost of time, some (mostly poor urban) households face additional costs from purchasing water from street vendors. Households with improved water access receive water either through piped supply of treated water sources (in house/outside tap) or have access to wells with pumps (mainly boreholes). Although the government policy is to provide domestic water to all consumers in urban areas and to around 90 percent of rural households by 2020, it is unlikely that this goal will be reached. According to a national water supply and sanitation survey conducted in 1993, the supply of potable water only reached about 76 percent of the urban and 46 percent of the rural population.

INSTITUTIONAL CHANGE IN GHANA'S WATER SECTOR

In the past, the Ghana Water and Sewage Cooperation (GWSC) had the mandate to provide an adequate supply of domestic water to the country's rural and urban population. Recognizing the GWSC's failure to fulfill this mandate, the Ghanaian government introduced—as part of its general decentralization policy for the public sector—institutional reforms in the domestic water sector, which are currently under implementation. As part of this reform process the urban and rural domestic water sectors were separated. In 1994, the government established the Community Water and Sanitation Project (CWSP) by launching the National Community Water and Sanitation Program (NCWSP). Initially the CWSP was part of GWSC, but later was turned into an autonomous institution known as the "Community Water and Sanitation Agency (CWSA)", responsible for rural drinking water supply and facilitating the implementation of the national community and sanitation strategy (established by Act 564, 1998). Urban water supply remained the responsibility of GWSC, which in July of 1999 was legally converted to a limited liability company - the Ghana Water Company Limited.[8]

REFORM OF RURAL WATER SUPPLY

The Community Water and Sanitation Agency seeks to transfer the ownership and management of water and sanitation services to rural communities and small towns to increase the sustainability of water supply and to enhance the control of water-borne diseases. This approach involves the communities in the design, planning, and operation of the supply systems, as well as in the financing of the necessary investments. Communities are also financially responsible for operation and maintenance. In contrast to the past this is a demand-driven

[8] In line with the Government's policy objectives in the domestic water sector, two additional institutions – the Water Resources Commission (WRC) and the Public Utilities Regulatory Commission (PURC) – have been set up. The PURC is responsible for approving water tariffs and to ensure proper water industry practices. The WRC, on the other hand, is empowered to oversee the sustainable utilization of the country's water resources and is responsible for water abstraction, pollution control, water quality standards, water rights, and license fees.

approach towards the provision of basic water supply and sanitation services. Women, who are mainly responsible for securing household water needs and for determining water use within the household, were given a central role in the design and management of the program within their communities. Participating communities have to contribute up to 5 percent of the total capital cost, as a means of registering ownership of the facility. In addition, it is expected that the communities are responsible for operation and maintenance costs of the facilities. In order to cover these costs, communities need to devise water charges, either through monthly water fees or through a "per-bucket" fee at the water service points. The private sector and NGOs were encouraged to participate in rural water supply provision, through the construction and maintenance of the facilities and the provision of equipment.

The institutional arrangements for implementing the national community and sanitation program comprise different levels of implementing bodies. The basic unit is the village, which forms a gender-balanced Water and Sanitation (WATSAN) committee. This committee is in charge of raising the initial community contribution to construction costs, and is responsible for the maintenance and operation of the water and sanitation systems. The committees work in close coordination with the district assemblies, which form the District Water and Sanitation Teams (DWST) that coordinate, supervise, and promote the project developments in the communities. Moreover, the CWSA has Regional Offices (RWSTs) that provide technical assistance to the district assemblies. CWSA is the overall primary responsible body, which guides, promotes, and monitors project activities. One goal of the program is to ensure that there is a minimum basic service of water – 20 liters per capita per day - which is protected all year, within 500 meters from the consumers and serving not more than 300 persons per water service point (Mensah 1998).

Up to now, the program seems to be fairly successful and approximately 40 percent of the rural population is participating in the program. CWSA's goal is to reach 85 percent of the rural population by 2009 (CWSA 2003). In order to foster the spread of the new supply strategy, CWSA also encourages NGOs to adapt their aid activities to the program and thereby to prevent any undermining of the policy. In addition, national and international NGOs are contracted to help with capacity building of local-level NGOs and community-based organizations (CBOs) as a basis for community mobilization.

The participatory approach of the CWSP is considered to be a major key to the success of the program. That structures for local and community management were already in place in Ghana certainly favored the new rural water supply policy. A national reform in 1983 had included a Decentralization Act that created and empowered district assemblies, a process well under way by the time the CWSA started its program (WSP-AF 2002). Today it is clear that transferring responsibility to district or communities needs time, as the capacity to cope with these responsibilities needs to first be developed. As individual households are expected to participate in construction and management decisions, including location and technology, there might be a need for educational advertising to point out the benefits of improved water supply and participation in related decision-making to communities. Moreover, the question of community cash contribution to capital costs is still being debated (WSP-AF 2002). In addition, little is known about who in the community effectively participates in the decision-making about water supply. Further insights would likely help to improve program design. This will be analyzed in the following.

4. ACCESS, USAGE, AND COST OF IMPROVED WATER SUPPLY

This section is based on a household water use survey carried out in the Ghanaian Volta basin during 2001, surveying a total of 503 households in 20 rural communities.

Water security in the Volta basin of Ghana relates to availability and access to safe water, which is closely related to investment in supply infrastructure and the management of domestic water supply, and varies across space and time. It also depends on the decision to use or not available sources of improved water, which is determined by price and income constraints as well as preferences, knowledge, and perceptions about water quality differences.

ACCESS TO WATER AND ACTUAL USE PATTERNS

Sources for domestic water supply in the basin are public pipes, boreholes, shallow wells, river, stream, and pond water, and rainwater. Households tend to use multiple water sources across seasons and for different purposes. They tend to depend on one major source, which is supplemented by additional sources. For example, 43.5 percent of interviewed households state that they use water from boreholes, but it is the major water source for only 32.5 percent (see Table 1). On average, households use two different sources for household water supply, which vary across seasons.

Table 1--Water sources used by the sampled households

	Sources used by the household in the past twelve month (in %) a/	Major water source used by the household (in %)
Piped water in the house or compound	2.6	2.6
Public Tap /standpipe	7.6	5.4
Private water vendor	5.4	1.4
Handdug well	18.6	12
Borehole	43.5	32.5
Water from neighbors	3.0	2.2
River, streams and ponds	57.5	42.1
Rainwater	64.3	1.2
Other	0.8	0.6
TOTAL	203.3	100.0

Note: a/More than one source could be named
Source: GLOWA Volta field survey [2001].

Out of the 20 communities surveyed, 15 have access to improved water supply. A household is defined to have access to an improved water source, if the community either has a borehole installed or if it is connected to the public piped system. The survey showed that although 71 percent of the surveyed households have access to improved water, more than half (59.5 percent) still rely on traditional, non-improved water sources—mainly surface water from river streams and ponds—as their main domestic water source. Moreover, 43 percent of households with access to an improved water source use unsafe water supply as their main domestic water source, either from hand-dug wells (43 percent), or surface sources from rivers, ponds, and streams (46 percent) (Table 2).

Table 2--Access to improved water supply and major water sources used for domestic water needs

	YES		NO
Household with access to improved water supply	**71% (355 cases)**		**29% (146 cases)**
	YES	**NO**	
Household using improved water sources as major water source	**57.2%**	**42.8%**	
Sources used for major water needs			
Piped water to house/compound	6.4%		
Public Tap	13.3%		
Borehole	80.3%		
Private Vendor		4.6%	
Handdug well		39.5%	
River, stream, pond		46.1%	96.6%
Rainwater		2.6%	1.4%
Other (e.g. water received from Neighbors)		7.2%	2.1%

Source: GLOWA Volta field survey [2001].

The alternative water source households rely on depends on the water availability in the respective area. Due to higher precipitation in the southern part of the basin, for example, rainwater harvesting seems to be a more important alternative to borehole supplies in that region, whereas boreholes are more important in the northern part of the Ghanaian basin.

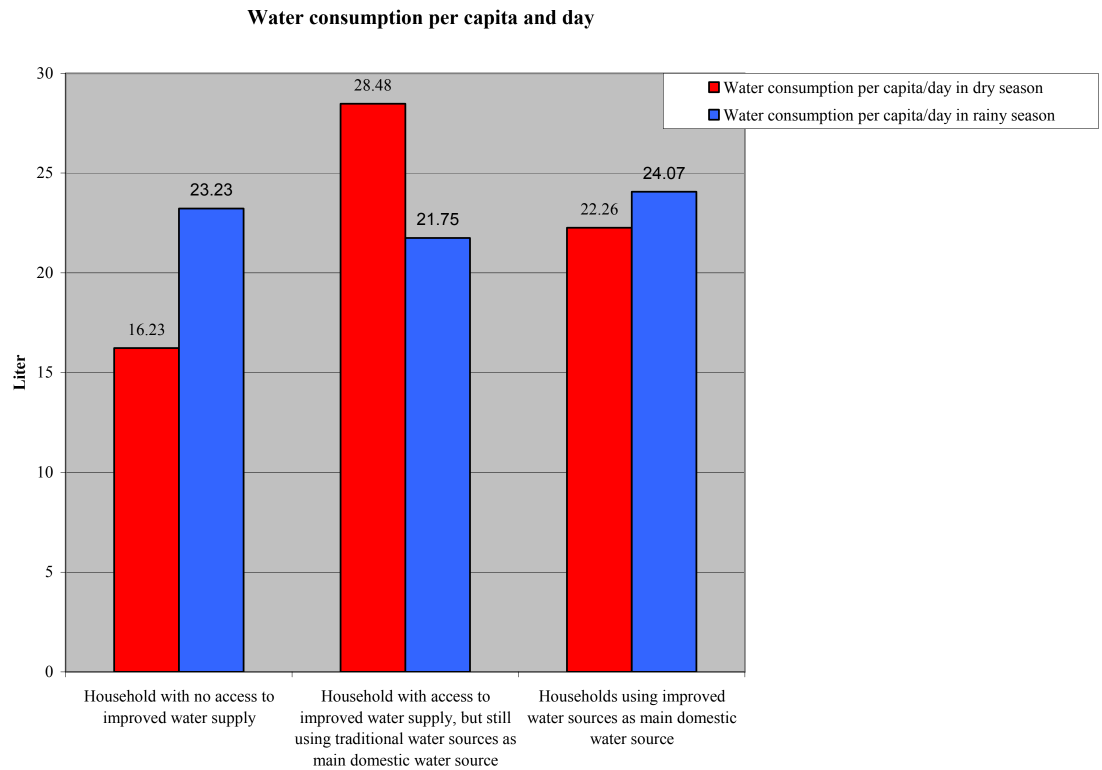
Among those households that have access to improved water supply, but continue to use streams and lakes as their main water source (70 cases or 20 percent of all households with improved access), only one fifth considers water from improved water sources (here boreholes) as the second most important source. The majority (60 percent out of the 70 cases) uses rainwater as the main alternative to surface water. Households using hand-dug wells as their main source (while having access to improved water supply) consider rainwater (27 percent), water from boreholes (22 percent), and surface water (13 percent) as their main alternative sources.

CONSUMPTION OF WATER

The daily average per capita water consumption for all domestic uses by the surveyed households is about 22 liters in the dry season and about 23 liters in the rainy season. Consumption differs by source of water. Three user groups can be defined along which consumption and expenditure patterns. *User group 1* has no direct access to improved water supply within the community and therefore mainly relies on surface water; *user group 2* has access, but uses non-improved water sources, such as water from shallow wells or surface water, as major water source for their daily water needs; and *user group 3* uses improved water supply as main domestic water source.

Households in group 1 consume less water per capita than households in group 3 using improved water supply, averaging 16 liters per capita in the dry season and 23 liters in the rainy season compared to 22 liters in the dry and 24 liters in the rainy season, respectively (see Figure 1). The difference in consumption between those two user groups is only statistically significant in the dry season, however. This is due to the real constraints imposed on households without access to safe water supplies in the dry season, with declines in supply reliability and increased opportunity costs for securing water, while rainwater harvesting is a readily available secondary source in the rainy season—85 percent of households using water from streams or ponds as main water source rely on rainwater as their second most important water source.

Figure 1--Water consumption patterns for different user groups



Thus, households using improved water supply have more stable consumption patterns, as the availability of these sources – public piped water and boreholes – generally does not vary by season. By contrast, households relying on non-improved water sources may face seasonal water shortages as one dimension of household water insecurity.

Households not only tend to combine different water sources, but also to vary their combination across seasons. The share of water accessed from improved water sources varies significantly between dry and rainy season for both user groups 2 and 3. The average share of water consumed from improved sources for the whole sample is 38 percent in the dry season and 29 percent in the rainy season. Households that access improved water supply as their main source for household needs (user group 3) cover 82 percent of their needs from this source in the dry season, but only 69 percent in the rainy season. For user group 2 the corresponding shares are 11 percent (dry season) and 8 percent (rainy season). Thus, the increased opportunity costs of collecting water in the dry season leads to a greater reliance on improved water supply during that season.

In addition, usage purposes vary by water source. For example, in the overall sample, 10 percent of households that use water from boreholes for drinking and cooking do not use it for bathing and laundry. Moreover, 18 percent of these households supplement their drinking water needs from surface water sources, particularly in the rainy season and about 30 percent state that they also rely on water from rivers, streams, and ponds for bathing and laundry. Moreover, nearly half of the households that use improved water sources as major water source also collect rainwater for all purposes, including for drinking and cooking.

HOUSEHOLD EXPENDITURES FOR WATER

Households in Ghana face both direct and indirect costs for obtaining water. Direct costs are monetary costs in the form of water charges, while indirect costs include opportunity costs of time for fetching water from distant places and, in some cases, transportation costs. Direct monetary costs are mostly incurred for water from the public piped system, private vendors, most boreholes, and sometimes also for wells. The water tariff for the piped system is subsidized and much lower than vendor water. At the time of the survey piped water charges were based on an increasing block tariff structure composed of 2 blocks: 0-10 m^3 at 990 Cedis per m^3 and more than 10 m^3 at 3,600 Cedis per m^3.[9] The official tariff for water from public standpipes was 1,000 Cedis/m^3 and the monthly flat fee for water from boreholes and wells with pumps was 3,000 Cedis per month.

[9] The average exchange rate for 2001 was 7.139 Cedis for US$1.

However, tariff designs vary in communities that manage the supply system themselves (see Table 3). Water from public taps is usually sold by unit, for example, bucket or basin, and the price varies between 25-100 Cedis per volume unit. As part of the Ghanaian policy of decentralizing rural water supplies, communal water and sanitation committees typically manage the boreholes. The operation and maintenance of these boreholes is typically financed through (1) sales of water per bucket, (2) fixed flat rate per household – to be paid monthly or yearly, (3) variable contribution per household (sometimes according to the number of adults in the household), or (4) payment when maintenance is necessary. Water from shallow wells is typically free of charge for community members; in some cases per bucket/basin or monthly flat fees are levied.

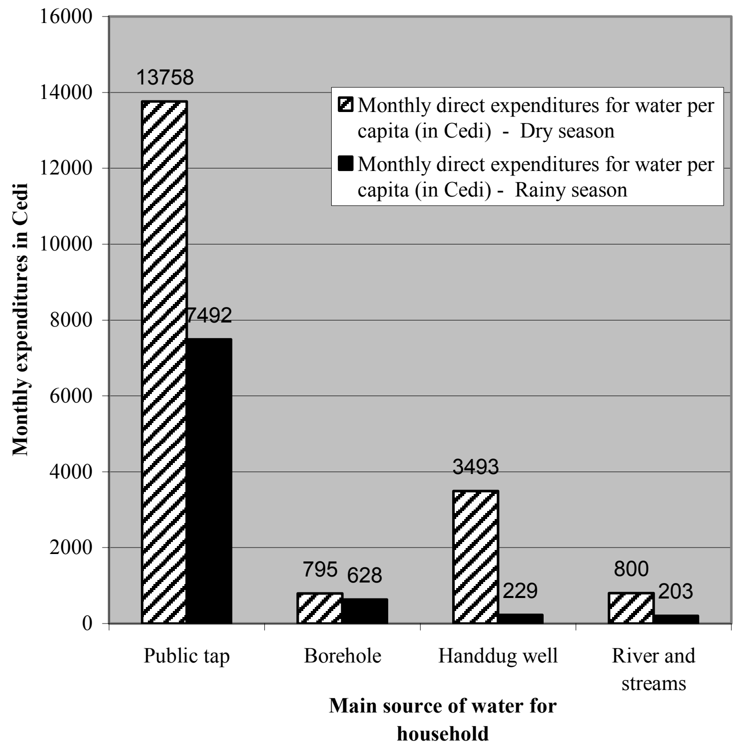
Table 3--Observed type of operation and maintenance fee (number of sampled communities)

	Payment per bucket	Flat rate	Contributions if repairs arise	No contributions
Public tap	2	-	-	-
Borehole	3	5	5	1
Hand dug well	1	2	-	4

Source: GLOWA Volta field survey [2001].

The analysis of household expenditures for water shows a clear contrast between seasons and with respect to the source used (see Figure 2). Average expenditures for domestic water per capita and month are 4,111 Cedis in the dry season and 2,911 Cedis in the rainy season, about 1.5 percent of per capita income. The seasonal variation of expenditures is mostly due to changes in water sources used and therefore costs incurred. During the rainy season, households tend to supplement their water needs with relatively cheap rainwater, which lowers overall expenditures. Moreover, in those areas where shallow wells go dry in the dry season, households need to switch to boreholes or water vendors as alternative—but more expensive—sources.

Figure 2--Expenditure for water per capital



Indirect water costs, such as opportunity costs of time for fetching water from distant places and transportation costs are particularly important for the 43 percent surveyed households that rely on surface water, without direct monetary expenditures. While not calculated in detail for this study, they likely play an important role in household water source decision-making processes. In our analysis below we use distance from the source as a, admittedly rough, proxy of indirect costs.

In summary, our descriptive analysis indicates that household water source and usage patterns differ significantly and seem to respond to changes in availability of alternatives and quality considerations for different uses. The results highlight the fact that—although the CWSP appears to be quite successful in providing access to improved sources for rural communities—many households in those communities continue to use unsafe water sources, undermining program targets. The determinants for household water choice will be analyzed in the following section.

5. WHY DO PEOPLE NOT USE IMPROVED WATER SOURCES?

To analyze this question we conduct an econometric analysis of factors that can explain why some households use the improved water source and others do not. For this purpose, we concentrate on the sub-sample of households living in communities with access to a borehole or public standpipe. In general, we would expect a household to choose the improved water source if the expected utility from doing so exceeds the expected utility from using the non-improved source. Mathematically, this condition can be written as

$$E(U_{iI}) - E(U_{iN}) \geq 0,$$

where U_{ij} denotes household i's indirect utility from using source j ($j \in \{I, N\}$), I denotes the improved source, and N denotes the unimproved source.

In econometric terms this relationship can be estimated as a Logit model with the dependent variable being a dummy reflecting whether the improved source was chosen by the household or not. This approach requires that the choice is mutually exclusive. Therefore, the focus was on the households' main domestic water source. Since households in the sample usually indicated multiple water sources, even for specific uses, it was not possible to conduct a multinomial logit analysis specifying the type of improved and non-improved sources chosen. Instead we included only those communities in the sample, which had access to a borehole or a public tap, and where no other improved source was available and focus on the choice of improved versus non-improved source as main domestic water source. Table 4 provides the definitions of the variables used in the regression analysis and the hypothesized direction of the effects. Specifically, we hypothesize the following determining factors of the household's choice of water source:

SUPPLY CHARACTERISTICS

The supply characteristics of the water source most likely to influence decisions on domestic use are price and quality. We would expect that the lower the cost for using an improved water source the higher the likelihood that households will use it. Households will also choose the improved water source if costs of alternative sources are higher, if its quality is perceived to be better, and if the perceived quality of the alternative source is lower. The main alternative source with information for all households is the river. A variable (DQRIV) was included that captures households' perception of river water quality. The quality of the improved source was not included in the regressions since there was very little variation in the dataset; nearly all households consider the quality of the improved water source to be good. As discussed in the previous section, the water cost for a source generally consists of the financial cost and the opportunity cost of the time spent collecting the water. To capture the opportunity cost of time, the difference in distance from the house to the river and to the improved source (DIFDIST) was included in the regressions. While the use of the river usually has no monetary cost, three possible price systems exist for the improved source in our sample: (i) per-bucket price, (ii) flat rate, and (iii) free-of-charge. In the first case, the household is charged a price for each unit of water extracted. Under a flat rate, the household is charged a fixed amount (on a per-household or per-person basis) once in a given time period and can then extract as much water as it wants. In some sites, no charge is applied for the water. However, households that use the water will likely be charged maintenance costs if repairs become necessary. Unfortunately, information on such maintenance expenses was not available. The per-bucket price represents the marginal price of water. By contrast, the flat rate is a fixed cost that has to be invested periodically if the household is to use improved water; the marginal price in this case would be zero. This difference is expected to have an important effect on some of the other hypothesized determinants. Therefore, the econometric analysis was conducted separately for these three sub-samples of the dataset.[10]

DEMAND CHARACTERISTICS

The decision whether to use the improved source or not is also hypothesized to depend on the overall water demand, which is proxied by household size (NETHHSIZ). Under a per-bucket price system, the price per unit of water translates into higher overall water expenses for larger households. Given income, we would therefore expect that larger households are less likely to use the improved source as their major water source. The effect is quite different for a flat-rate system, where we would expect larger households to be more likely to use the improved source. For communities without direct water charges, the effect is less clear. However, if households under this system are charged repair costs as they arise and if those are distributed on a per household basis, then the effect would be similar to that in the flat rate.

Furthermore, household income and preferences are likely to affect the demand for improved water. One important potential hypothesis is that poor households may not be able to afford to pay for improved water at the rates set by the communities. To test for this effect, we include an income proxy based on roof quality (ROOF). If income restricts the ability of households to use the improved source, higher-income households should be more likely to use it than lower-income households.

Finally, age, education, and gender of the household head (HEADAGE, DEDUC, and SEXHEAD) were included as proxies for preferences. The effect of age is generally ambiguous. On the one hand, it is hypothesized that older people prefer to keep up traditions and are therefore less likely to use the improved source. On the other hand, older people could be more

[10] Communities where two or more price systems coexisted were excluded from the analysis.

knowledgeable about the potential health problems associated with the consumption of unimproved water. Similarly, we would expect more educated people to be more aware of the health issues and therefore more likely to use the improved source. Finally, women are hypothesized to care more about the health of their family, making them more likely to use the improved source. A second set of regressions was run including these characteristics for the person indicated to take decisions on water rather than the household head.

Table 4--Definitions of variables used in econometric analysis on probability of using the improved source as main water source and hypothesized effects

Variable	Definition	Expected effect
IMPROV	Dummy variable, =1 if main water source is an improved source, =0 otherwise	Dependent var.
HEADAGE	Age of household head	?
DEDUC	Dummy variable, =1 if household head has no formal education, =0 otherwise	+
DIFDIST	Difference in distance between the river and the improved source	+
PIMP	Per bucket price of improved water	-
FCAP	Flat rate per capita	-
DQRIV	Dummy for perceived quality of the river (0=bad, 1=good)	-
ROOF	Roof quality dummy (=0 if mud, thatch, or wood, =1 if iron sheet, cement, or asbestos)	+
SEXHEAD	Gender of the household head (=1 if female, =0 if male)	+
NETHHSIZ	Size of household excluding members not living at home	- for per bucket + for flat rate and zero price

Table 5 presents selected descriptive statistics for the three sub-samples. The average use of improved water varies across the different sub-samples. Forty-two percent of households facing per-bucket pricing systems use the improved water source, while 89 percent of households in communities with flat-rate systems and 48 percent of households without direct charges use the improved source. All the communities with the per-bucket price in this sample are located in the southern regions (characterized by higher income and education levels than the poorer north), while most of the systems without a direct water charge are located in the North. Communities with flat-rate systems are distributed evenly in both areas. Even though the per-bucket price appears much lower than the flat rate paid by households, calculations of the effective per-liter price of water show that paying a flat rate results in a much lower price per liter (0.22 cedis per liter) than a per-bucket system (3 cedis per liter). However, the flat-rate system typically requires payment in advance of the entire amount. The *per capita* consumption of improved water in the communities that pay a per-bucket-price is less than half the *per capita* consumption in the communities that pay a flat rate and also lower than the consumption in communities that face no direct water charge. This is intuitive given the lower effective price per liter and the fact that the marginal price of water under the flat-rate system is zero.

Table 5--Descriptive statistics by subsample

	Per Bucket Pricing					Flat rate					Zero Price				
	Mean	**Std.Dev.**	**Min**	**Max**	**N**	**Mean**	**Std.Dev.**	**Min**	**Max**	**N**	**Mean**	**Std.Dev.**	**Min**	**Max**	**N**
AVGROUP	1,80	0,58	1,04	2,67	95	2,06	0,17	1,88	2,22	53	2,15	0,41	1,56	2,59	105
CIMPPC	176,27	267,20	0,00	1080,00	95	416,39	528,90	0,00	2731,20	53	225,73	312,70	0,00	1344,00	105
DEDUC	0,64	0,48	0,00	1,00	87	0,49	0,50	0,00	1,00	53	0,37	0,49	0,00	1,00	105
DEDUCW	0,60	0,49	0,00	1,00	95	0,40	0,49	0,00	1,00	53	0,31	0,47	0,00	1,00	105
DIFDIST	-727	1684	-7500	3800	95	543	367	-303	1190	53	117	325	-700	1113	105
DISTIMP	1332	1695	70	8000	95	312	260	10	1000	53	474	253	20	1000	105
DISTRIV	604	503	55	4000	95	855	400	80	1600	53	591	190	100	1563	105
DQRIV	0,51	0,50	0,00	1,00	95	0,19	0,39	0,00	1,00	53	0,30	0,46	0,00	1,00	105
ETHNI	0,80	0,40	0,00	1,00	95	0,96	0,19	0,00	1,00	53	0,85	0,36	0,00	1,00	105
FCAP	0,00	0,00	0,00	0,00	95	60,54	65,76	9,26	489,58	53	1,60	16,44	0,00	168,42	105
FEMPROP	0,51	0,19	0,00	1,00	94	0,47	0,17	0,00	0,80	53	0,52	0,16	0,00	0,86	105
HEADAGE	49	14	22	85	94	60	15	34	105	53	49	14	1	90	105
IMPROV	0,42	0,50	0,00	1,00	95	0,89	0,32	0,00	1,00	53	0,48	0,50	0,00	1,00	105
KIDS	3,75	2,59	0,00	14,00	95	4,47	2,84	0,00	11,00	53	4,22	2,84	0,00	14,00	105
NETHHSIZ	8,82	7,16	1,00	66,00	95	11,53	5,93	1,00	37,00	53	10,34	4,32	1,00	20,00	105
PARTIC	0,52	0,51	0,00	1,00	46	0,28	0,46	0,00	1,00	46	0,20	0,40	0,00	1,00	66
PIMP	4,32	2,19	0,00	11,11	95						0,00	0,00	0,00	0,00	49
PPCAPITA	151319	319315	18035	2842280	95	92705	121427	11747	696454	53	75301	84628	8444	742688	105
ROOF	0,89	0,31	0,00	1,00	93	0,77	0,42	0,00	1,00	53	0,63	0,49	0,00	1,00	104
SEXHEAD	0,27	0,44	0,00	1,00	94	0,06	0,23	0,00	1,00	53	0,21	0,41	0,00	1,00	105
SEXWAT	0,59	0,50	0,00	1,00	94	0,34	0,48	0,00	1,00	53	0,74	0,44	0,00	1,00	105

The results of the econometric analysis are presented in Table 6. In general, the estimated coefficients have the expected signs, with few exceptions. The perceived quality of the river water consistently has a highly significant effect on the choice of water source under all three pricing systems. Unfortunately, the data did not permit us to analyze to what degree differences in perceived quality are caused by actual differences in quality as opposed to differences in awareness. To shed more light on what underlies quality perceptions, Table 7 presents these perceptions differentiated by specific characteristics of the water. Households appear to be mainly concerned about potential infections, followed by particles, color, and smell of the water.

As expected, the probability of using the improved source decreases with price and increases with income in the communities where a positive price is charged. Interestingly, price is significant while income is not in the communities charging a per-unit price, and the reverse is true in those communities where a flat rate is charged. Thus, where households have to pay each time they consume water, they are more responsive to the price charged (and thus might reduce their quantity consumed) while income is not a constraint. This is consistent with the observation that water expenditures are quite low in relation to income. However, where a one-time payment has to be made in advance (flat rate), income becomes the constraining factor, rather than the actual level of the flat rate. As discussed earlier, the effective per-unit price is actually much lower under the flat-rate system. The significant effect of income in these communities indicates that poorer households may face difficulties in making a one-time payment upfront, which could keep them from using the improved source. As expected, the effect of income is less clear in the communities applying a no-charge system. While it is only significant at the 17 percent level, its negative sign is a bit puzzling.

Opportunity costs also matter. The further the distance from the river as compared to the distance from the improved source, the more likely the household uses the improved source. The effect is, however, only significant in communities charging a flat rate.

As expected, larger households are less likely to use the improved source in communities charging per bucket and more likely to use it where a flat rate or no charge is applied. The effect is, however, not significant. For the flat rate this makes sense given the fact that the flat rate *per capita* was included in the regression.

Age, as expected, has an ambiguous effect on the demand for an improved water source and is only close to significant in those communities charging a flat rate, where it has a positive effect. Education has the expected positive effect, but is only significant for communities charging a per-bucket price. This may be due to the fact that the perceived water quality already captures differences in awareness about health issues. Households headed by women are significantly more likely to use the improved source in communities charging a flat rate, while the effect is reversed yet insignificant in the other two cases. As indicated above, the same set of regressions was rerun including characteristics of the person in the household who takes domestic water use decisions rather than those of the household head. The results were the same for the per-bucket and repair charge only cases. Results changed only for the flat rate system, where the characteristics of the household head seemed to be more relevant. This is intuitive, given the fact that the decision to use improved water under a flat rate system involves a fairly high one-time payment, a decision, which may well be taken by the household head.

Table 6--Results of econometric analysis on determinants for improved water source

Per bucket pricing

Variable	Coefficient	Std.Err.	P-value
Constant	7,430	4,432	0,094
HEADAGE	0,004	0,043	0,923
DEDUC	2,838	1,387	0,041
DIFDIST	0,000	0,001	0,806
PIMP	-2,076	0,586	0,000
DQRIV	-3,295	1,297	0,011
ROOF	0,724	3,707	0,845
SEXHEAD	1,871	1,206	0,121
NETHHSIZ	0-0.065	0,154	0,674

Dependent variable	IMPROV
Number of observations	85
Log likelihood function	-15,27568
Restricted log likelihood	-57,91948
Chi-squared	85,28761
Significance level	0
Percentage of cases predicted correctly	94,1

Flat rate

Variable	Coefficient	Std.Err.	P-value
Constant	-9,237	5,654	0,102
HEADAGE	0,108	0,069	0,118
DEDUC	0,856	1,275	0,502
DIFDIST	0,005	0,002	0,050
FCAP	0,003	0,017	0,868
DQRIV	-2,694	1,306	0,039
ROOF	2,895	1,739	0,096
SEXHEAD	-3,713	2,112	0,079
NETHHSIZ	0,156	0,198	0,430

Dependent variable	IMPROV
Number of observations	53
Log likelihood function	-11,70663
Restricted log likelihood	-18,71798
Chi-squared	14,0227
Significance level	8,12E-02
Percentage of cases predicted correctly	90,6

Zero price

Variable	Coefficient	Std.Err.	P-value
Constant	0,153	1,009	0,880
HEADAGE	-0,008	0,018	0,630
DEDUC	0,061	0,550	0,911
DIFDIST	0,000	0,001	0,582
	...	...	...
DQRIV	-2,211	0,649	0,001
ROOF	-0,716	0,512	0,162
SEXHEAD	0,648	0,638	0,310
NETHHSIZ	0,108	0,055	0,051

Dependent variable	IMPROV
Number of observations	104
Log likelihood function	-57,87122
Restricted log likelihood	-72,01036
Chi-squared	28,27829
Significance level	1,96E-04
Percentage of cases predicted correctly	72,1

Table 7--Respondents' water quality perceptions differentiated by specific characteristics

Proportion of households worried about different quality aspects

	Pipe	Vendor	Public Tap	Borehole	Hand-dug well	Collected Rainwater	River, Streams, Ponds…
Particles	0.01	0.03	0.01	0.02	0.09	0.10	0.35
Color	0.00	0.02	0.02	0.04	0.06	0.03	0.35
Smell	0.00	0.00	0.01	0.03	0.03	0.00	0.22
Taste	0.02	0.04	0.00	0.07	0.04	0.01	0.07
Salinity	0.01	0.01	0.01	0.06	0.01	0.00	0.01
Fear of Infections	0.00	0.02	0.01	0.01	0.07	0.04	0.44

Our analysis so far only considered whether a household chooses the improved water source as the main source or not. In order to examine the determinants of the actual quantity of the improved water used, a two-stage Heckman analysis was conducted for the sub-sample of communities charging a per-bucket price.[11] In the first stage, the probability of a household using the improved source was estimated using the specification explained above. In the second stage, the *per capita* quantity of improved water used by the households was analyzed, including the inverted Mills ratio from the first stage to correct for selectivity bias. Variables included and their

[11] For the other communities, quantity demanded and per-unit price are linked. This would make the analysis more complicated. The issue is left for future analysis.

expected effects on the quantity used are given in Table 8. The results of the second stage are presented in Table 9. Two versions are reported here, one including the characteristics of the household head, and one including the characteristics of the person deciding on household water use. In general, the results are similar, with the formulation for the household head having slightly higher predictive power.

The reasoning behind the variables included is similar to the one described earlier for the choice of water source. As one would expect, the price per bucket has a highly significant negative effect on the quantity of improved water consumed. Perceived quality of river water is also significant. We would expect that distance to the improved source and the river decreases and increases the quantity of improved water demanded, respectively. The results indicate, however, that these effects are insignificant, as is the income effect. These results are in line with our earlier results for the probability of using improved water in communities charging per bucket of water used. Education of the household head has a significant positive effect on the quantity of improved water demanded, while the level of education of the person taking decisions on domestic water use is less significant. Gender and household size have the expected signs, but are not significant. The proportion of children in total household size was included to capture two possible effects. On the one hand, children tend to consume less than adults. On the other hand, health effects of consuming unimproved water may be more severe for children. Since these two effects are counteracting each other, it is not surprising that the results show an insignificant overall effect.

It is likely that there are correlation problems due to the inclusion of similar variables in the first and second stage. It is all the more interesting, however, that the strong effect of quality perceptions and price prevails.

Table 8--Variables included in econometric analysis on quantity of improved water demanded and expected effects

Variable	Definition	Expected effect
CIMPPC	Per capita consumption of improved water	Dependent var.
KIDPROP	Proportion of children below the age of 18 in NETHHSIZ	?
DEDUC	Dummy variable, =1 if household head has no formal education, =0 otherwise	+
DEDUCW	Dummy variable, =1 if person indicated to take decisions on water in household has no formal education, =0 otherwise	+
DISTRIV	Distance to the river	+
DISTIMP	Distance to improved water source	-
PIMP	Per bucket price of improved water	-
DQRIV	Dummy for perceived quality of the river (0=bad, 1=good)	-
ROOF	Roof quality dummy (=0 if mud, thatch, or wood, =1 if iron sheet, cement, or asbestos)	+
SEXHEAD	Gender of the household head (=1 if female, =0 if male)	+
SEXWAT	Gender of person indicated to take decisions on water in household (=1 if female, =0 if male)	+
NETHHSIZ	Size of household excluding members not living at home	-
IMR	Inverted Mills ratio from first stage	

Table 9--Results of econometric analysis on quantity of improved water demanded (Heckman model, second stage)

a) including characteristics of person taking decisions on water				b) including characteristics of household head			
Variable	***Coeff.***	***Std.Err.***	***P-value***	**Variable**	***Coeff.***	***Std.Err.***	***P-value***
Constant	532.830	132.358	0.000	***Constant***	497.571	129.225	0.000
KIDPROP	1.210	1.467	0.412	*KIDPROP*	1.538	1.449	0.292
DEDUCW	60.324	56.550	0.290	*DEDUC*	117.504	59.481	0.052
DISTRIV	-0.006	0.051	0.901	*DISTRIV*	0.000	0.050	0.993
DISTIMP	-0.001	0.022	0.980	*DISTIMP*	-0.001	0.022	0.977
PIMP11	-56.823	15.456	0.000	*PIMP11*	-56.585	15.458	0.001
DQRIV2	108.155	61.102	0.081	*DQRIV2*	-119.089	60.090	0.051
ROOF	5.289	94.126	0.955	*ROOF*	-26.417	93.782	0.779
SEXWAT	32.714	54.040	0.547	*SEXHEAD*	79.930	62.345	0.204
NETHHSIZ	-18.031	14.516	0.218	*NETHHSIZ*	-16.506	14.140	0.247
IMR	91.982	64.412	0.158	*IMR*	105.113	62.048	0.095
Dependent variable			CIMPPC	Dependent variable			CIMPPC
Number of observations			85	Number of observations			85
R-squared			0.396119	R-squared			0.419888
Adjusted R-squared			0.31451	Adjusted R-squared			0.34149
Significance level			0.00	Significance level			0.00

6. WHO PARTICIPATES IN DECISION-MAKING ON IMPROVED WATER SUPPLY AND WHY?

Our results have indicated that supply characteristics matter in a household's decision to use an improved water source. Given the participatory approach adopted by CWSA, the question arises who in the community actually participates in decisions regarding these characteristics and why. To address this question additional analyses were carried out.

DESCRIPTIVE ANALYSIS

Out of the 355 households interviewed with access to improved water supply, 287 households answered the question whether they participated in the location and design of the improved water source. However, 61 percent of these households stated that they did not participate at all; 28 percent participated in the selection of the location; 9 percent in the selection of the technology (for example, type of pump), and 22 percent said that they participated in both decisions (see Table 10).

Table 10--Participation in decisionmaking on location and technology of improved water source

	No participation	Yes , only in location	Yes, only technology	Yes, both – location and technology	Total
Improved supply	176 (61%)	80 (28%)	9 (3%)	22 (8%)I	287 (100%)
Public tap	23	15	7	4	49
Borehole	153	65	2	18	238

At the same time, there appeared to be quite a strong sense of communal ownership regarding the public water source. When asked 'Who in your opinion is owning the public supply facilities?' the most frequent answer was 'the community'. Only few respondents considered the Ghana Water Company or the Water and Sanitation committee itself to be the owner. Most households understood the concept behind the Water and Sanitation committees and felt well represented, including the ability to monitor decisions taken by the committee. Furthermore, about half of the households with access to improved water supply stated that they contribute financially to the operation and maintenance of the water supply facilities. Seventy percent of these consider the community itself (rather than e.g. GWCL, CWSA or any NGO) to be the decision-making organization for cost recovery within the community.

ECONOMETRIC ANALYSIS

Regarding the determinants of participation in decisions on the location and technology of the improved water source, we would expect a household to participate if the expected benefits from participation exceed the costs. The definitions of variables included in the analysis and the expected signs are presented in Table 11.

Expected benefits from participation

a) Potential benefits from influencing outcomes: We expect that a household is more likely to participate in decisions on improved water supply the higher its potential benefits in case it can influence outcomes (location, technology) in its favor. These are, for example, higher the more likely the household will actually use the improved source later on. Of course, the likelihood of using the improved source is endogenous. We include the predicted value from our earlier regressions (APROP) as an explanatory variable here. Potential benefits also depend on how high the household actually values the use of the improved water. For example, women may not only be more likely to end up using the improved source, but they may also value the positive health impacts higher than men.

b) Bargaining power: Even if a household is likely to use the improved source later on and values its use highly, it may decide not to participate in meetings on the issue if it is not likely to have an actual impact on decision-making. In other words, participation does not automatically imply having an influence over the actual location or technology chosen due to differences in bargaining power across households (Weinberger and Juetting, 2002). We include the following proxies for bargaining power: education, income, age, and gender of the person taking decisions on water, ethnicity, as well as average group membership in the community.[12] We hypothesize that more educated and higher-income members of the community have more bargaining power and are thus more likely to participate in decision-making about improved water supply. We also expect older, male community members to be more respected in the traditional Ghanaian communities and therefore to be more likely to participate as compared to younger, female members. A further hypothesis is that bargaining power, and thus the probability of participation,

[12] Including the characteristics of the household head instead did not change the results in qualitative terms, but reduced the significance level somewhat. This may be due to the correlation with the predicted probability of using the improved source, which was based on household head characteristics.

is higher if the household belongs to the dominant ethnic group in the community. Finally, relative bargaining power depends on how many other members of the community are expected to participate as well. To capture this effect, we follow the literature on social capital and include the average number of groups that the people living in a particular community are members of (AVGROUP) as a further explanatory variable. The hypothesis is that the larger this number, the more people the household expects to appear at the decision-making meeting and thus the lower its own chances to influence the outcome in its favor. Thus, the expected effect on participation is negative.

Expected costs of participation

Participation is associated with opportunity costs. Unfortunately, exact data on households' opportunity costs of time were not available for our analysis. One proxy for opportunity costs could be the proportion of females in total household size, the idea being that women may be perceived to have lower opportunity costs.[13] We also hypothesize that opportunity costs are related to education and possibly income. Illiterate, poor people (particularly the landless) operating at the subsistence limit are usually considered to have very high opportunity costs. Opportunity costs tend to be lower for middle-income households. Rich, highly educated people may have high or low opportunity costs. They may have employees farming on their land, reducing their own opportunity costs; but they may also work off-farm with potentially high opportunity costs. Thus, opportunity costs may decrease monotonically with income and education or may follow a U-shape. Correspondingly, the opportunity cost effect is hypothesized to lead to an increasing or inverted U-shaped effect of income and education on participation.

[13] We do not intend to say that women have actually lower opportunity costs, but rather that they may be perceived to have lower opportunity costs in Ghanaian communities.

Table 11--Variables included in econometric analysis of determinants of participation in decisions on improved water supply and expected effects

Variable	Definition	Expected effect
PARTIC	Dummy variable, =1 if household member participated in decisionmaking over location or technique of improved source, =0 otherwise	Dependent var.
HEADAGE	Age of household head	+
EDUW0	Dummy variable, =1 if person indicated to take decisions on water in household has no formal education, =0 otherwise	? (+ opportunity cost effect, - bargaining power effect)
EDUW2	Dummy variable, =1 if person indicated to take decisions on water in household has secondary education or more, =0 otherwise	? (? opportunity cost effect, + bargaining power effect)
SEXWAT	Gender of person indicated to take decisions on water in household (=1 if female, =0 if male)	? (+ potential benefits effect, - bargaining power effect)
FEMPROP	Proportion of females in NETHHSIZ	+
APROP	Predicted probability of using the improved water source as main water source	+
HIGH20	Dummy variable, =1 if household belongs to top 20 percent in the sample in terms of per capita expenditures, =0 otherwise	? (? opportunity cost effect, + bargaining power effect)
LOW20	Dummy variable, =1 if household belongs to lowest 20 percent in the sample in terms of per capita expenditures, =0 otherwise	? (+ opportunity cost effect, - bargaining power effect)
PPCAPITA	Per capita expenditures	+
AVGROUP	Average number of groups in which people participate in the community that the household belongs to	-
ETHNI	Dummy variable, =1 if household belongs to main ethnic group in the community, =0 otherwise	+

The results of the econometric analysis are presented in Table 12. Two pairs of regressions are reported. First, regressions are reported for a subset including only communities where a water charge was applied (per bucket or flat rate), and then for the full sample including all three sub-samples from our earlier analysis (per bucket, flat rate, and repair costs only). This was done because we feel that our knowledge about the latter price system is somewhat limited due to the fact that information on *ex post* payments for maintenance costs was not available. Second, for each sample two versions of income variables were used: (i) a linear per capita expenditure variable (PPCAPITA), and (ii) dummy variables for the highest and lowest income quintiles of the population.[14]

In general the results are quite robust to specification, but tend to yield more significant effects when the sample is reduced to communities applying a water charge. The ethnicity variable could not be included in the smaller sample regressions due to a lack of variation. The results for the other variables, however, do not change when the ethnicity variable is also excluded from the full sample regression. The analysis yields several interesting results.

First, the results indicate that bargaining effects seem to be more significant than the effect of potential benefits. Specifically, the predicted probability of using the improved source later on has the expected positive effect on participation, but is insignificant. Being female has a significant negative effect in three of the four specifications, indicating that the bargaining effect dominates the potential benefit effect. Age has a consistently significant effect, although its negative sign is somewhat puzzling. One potential explanation is that younger people are more easily interested in the supply of new water sources. Ethnicity has the expected effect, but is not significant. The average group membership in the community, used as a proxy for others'

[14] Including a squared term of PPCAPITA was not feasible due to a strong correlation with the variable itself. Other versions of dummies (e.g. highest and lowest quarter) were tried, but showed less significant effects. The results discussed in what follows seem to thus hold only for the extreme income quintiles.

expected participation and thus own relative bargaining power, has the hypothesized negative effect and is highly significant in the reduced sample regressions. Where per capita income is included the effect is significant and positive, which is also consistent with bargaining power being very important.

The proportion of females as a proxy for opportunity costs shows the expected sign, but is not significant. As we have argued earlier, income and education can influence both bargaining power (with an expected positive effect) and opportunity cost (leading to an expected positive or inverted U-shaped effect on participation).[15] Our results indicate very consistently that education has what we call an *extremes effect* as opposed to the *middle-class effect* found by Weinberger and Juetting (2002). The effect is significant and very robust to changes in specification. It indicates that persons with high education (secondary or higher) as well as those with no education participate more than those with medium education levels. A similar effect is found for income. Rich households (highest quintile in terms of per capita expenditures) and very poor households (belonging to the lowest 20 percent) are both more likely to participate, although the effect of poor households is generally smaller and only significant in the reduced-sample regression. For highly educated and the richest members of the community the effect is consistent with the idea that these members have high bargaining power. Those members have very high chances to actually influence community decision-making in their favor and therefore participate. The effect is also consistent with the consideration of opportunity costs if these are relatively low for richer segments of the community.[16] For middle-income households with medium education chances are that they cannot compete in terms of bargaining power with the rich and highly

[15] Of course, per capita expenditures (our measure of income) are potentially endogenous and could depend on education levels. In our sample, however, the correlation was limited. For example, excluding the income proxies to run the reduced form did not affect the results on education and other variables.
[16] There may also be additional social reasons such as the custom for community elites to always attend any important meeting.

educated. As a consequence, the 'middle class' is less likely to participate. The result that the poor are relatively likely to participate is, however, somewhat puzzling. Why do the poor and uneducated participate despite having little bargaining power and high opportunity costs? A possible explanation is the following. Participation by poor segments of the community could be demand-driven. Programs like CWSA often strongly emphasize the need to include the poor. If government officials and/or community leaders could be successful in getting the poor to attend, potentially by providing incentives like free meals[17] or simply persuasion, this would explain the participation of the poor, whether their inclusion implies real bargaining power or not. Of course, high opportunity costs may prevent this from happening. In this regard it is important to note that the decision-making process considered—namely the choice of technology and location of the water source—does not require a large number of regular meetings. Rather this is a case of a single or perhaps a few meetings. In this sense, opportunity costs are likely to play less of a role in a household's decision to participate or not than if the decision was to join a group meeting regularly, as was the case, for example, in the study of Weinberger and Juetting (2002). The idea that opportunity costs play less of a role in our case is also consistent with the high participation of the high-income households.

It should also be stressed that average incomes in our sample are quite low. Thus, our 'middle class' is still poor by most standards. This may also explain why we get different results from Weinberger and Juetting. Clearly, more research is needed before generalizing these outcomes.

[17] Unfortunately, information was not available whether such incentives were provided in the cases studied here.

Table 12--Results of econometric analysis on determinants of participation in decisions on improved water supply

a) Including sub-sample of per bucket and flat rate communities only

1) with income class dummy

Variable	*Coeff.*	*Std.Err.*	*P-value*
Constant	17.606	6.902	0.011
HEADAGE	-0.082	0.036	0.025
EDUW0	3.030	1.139	0.008
EDUW2	4.016	2.249	0.074
SEXWAT	-3.037	1.123	0.007
FEMPROP	0.886	2.110	0.675
APROP	0.570	2.607	0.827
HIGH20	2.554	1.034	0.014
LOW20	2.048	1.072	0.056
AVGROUP	-8.424	2.987	0.005

Dependent variable	PARTIC
Number of observations	63
Log likelihood function	-24.58865
Restricted log likelihood	-40.7581
Chi-squared	32.3389
Significance level	1.74E-04
% of cases predicted correctly	79.40%

2) with per capita income

Variable	*Coeff.*	*Std.Err.*	*P-value*
Constant	12.457	6.080	0.041
HEADAGE	-0.062	0.031	0.042
EDUW0	2.555	1.003	0.011
EDUW2	2.731	1.814	0.132
SEXWAT	-2.256	0.918	0.014
FEMPROP	0.504	2.072	0.808
APROP	2.057	2.416	0.395
PPCAPITA	4.97E-06	2.80E-06	0.076
AVGROUP	-6.623	2.675	0.013

Dependent variable	PARTIC
Number of observations	63
Log likelihood function	-26.97617
Restricted log likelihood	-40.7581
Chi-squared	27.56386
Significance level	5.65E-04
% of cases predicted correctly	76.20%

b) Including also communities with zero price

1) with income class dummy

Variable	*Coeff.*	*Std.Err.*	*P-value*
Constant	1.642	3.316	0.621
HEADAGE	-0.035	0.019	0.069
EDUW0	1.699	0.675	0.012
EDUW2	3.981	1.388	0.004
SEXWAT	-1.197	0.563	0.034
FEMPROP	2.058	1.687	0.223
APROP	0.072	1.490	0.961
HIGH20	0.979	0.647	0.131
LOW20	0.184	0.729	0.801
AVGROUP	-1.707	1.185	0.150
ETHNI	1.053	1.163	0.365

Dependent variable	PARTIC
Number of observations	96
Log likelihood function	-48.2863
Restricted log likelihood	-60.3887
Chi-squared	24.20479
Significance level	7.07E-03
% of cases predicted correctly	75.00%

2) with per capita income

Variable	*Coeff.*	*Std.Err.*	*P-value*
Constant	0.770	3.480	0.825
HEADAGE	-0.034	0.019	0.074
EDUW0	1.704	0.680	0.012
EDUW2	3.960	1.386	0.004
SEXWAT	-1.134	0.562	0.044
FEMPROP	1.983	1.666	0.234
APROP	0.461	1.467	0.753
PPCAPITA	5.06E-06	3.04E-06	0.096
AVGROUP	-1.409	1.195	0.238
ETHNI	0.737	1.075	0.493

Dependent variable	PARTIC
Number of observations	96
Log likelihood function	-47.59716
Restricted log likelihood	-60.38865
Chi-squared	25.58298
Significance level	2.39E-03
% of cases predicted correctly	78.10%

7. CONCLUSIONS AND POLICY IMPLICATIONS

We have examined access to, use of, and participation in decisions on improved water supply in the Volta basin of Ghana, one of the first countries to introduce a community-based approach to rural water supply on a large scale. Our results indicate that 71 percent of the households interviewed in the basin have access to improved water, which seems reasonably close to the CWSA's target of 85 percent by the year 2009. However, access does not imply that all households in these communities actually use the improved source. Our analysis shows that 43 percent of households with access to an improved source prefer alternative, less safe sources as their main domestic water source. Moreover, even those households using improved sources typically supplement their water needs with other sources, even for drinking and cooking purposes. This has potentially adverse health implications and points to the need to better understand household decision-making for domestic water use, which was the purpose of this paper.

Our results indicate that quality perceptions play an important role in households' choice of water source. Specifically, households that consider the unimproved source to be of bad quality are significantly more likely to choose the improved source as their main water source. Differences in quality perceptions across households can be due to either actual quality differences or to differences in awareness. If the latter is the case, there is an important role for education and awareness building. More research is therefore needed on the underlying causes of the variation in quality perceptions.

Relative distances to improved and unimproved sources also matters to some extent as it translates into opportunity costs of time for reaching the source. Thus, the provision of more improved water sources to reduce distances is likely to increase households' use of such sources.

The effect of prices and income levels on households' choice of water source differs according to the pricing system used. In particular, price matters where a per-unit price is charged. Under such a system, household behavior is sensitive to the price charged, regardless of income. Price and quality also have a significant impact on the quantity of improved water consumed in these communities. Where a flat rate is charged, income level plays a more important role than price. This is intuitive as the effective per-unit price charged in these communities tends to be low, but the one-time payment required can be problematic for poorer households, particularly in the context of imperfect credit markets. This points to the importance of choosing an appropriate pricing system to prevent exclusion of the poor. For example, a flat rate system allowing poor households to pay in installments may be useful to ensure that poorer households are reached.

Given that supply characteristics such as the location and pricing system affect household decisions to use the improved source, households may try to influence these characteristics in their favor during the community decision-making process for the improved source. Yet our results shows that less than 40 percent of the households interviewed participated in decisions on location or technology. This raises the question of what determines whether a household participates or not. We argue that this decision, in principle, depends on three main factors: (i) the household's bargaining power, i.e., how likely the household's participation is to result in influencing supply characteristics in its favor, (ii) the potential benefits from such influence, e.g., the probability of actually using the improved source, and (iii) the cost of participation, i.e., mainly the opportunity cost of time. Our results indicate that bargaining power matters more than potential benefits, that is, bargaining power is important in Ghanaian communities. Moreover, contrary to the middle-class effect discussed elsewhere (Weinberger and Juetting 2002), we find what we call an *extremes effect:* the poorest, uneducated and the richest, highly educated segments of the community are more likely to participate in decision-making for improved domestic water supply than the middle class. The high attendance of the richer segments is consistent with the idea that bargaining power increases with income and education, while participation by the poor and uneducated may be demand-driven as these are specifically targeted by CWSP. Opportunity costs are likely to have less of an effect in the context studied here where the issue is one of participating in one or few meetings only, as compared to other studies discussing participation in regular groups meetings. Further research on other aspects of participation, for example, membership in WATSAN committees, which take additional decisions regarding domestic water supplies and meet more regularly, as well as for similar issues in other countries would be desirable to further test the empirical relevance of the *extremes effect*.

REFERENCES

Altaf, Mir Anjum. 1994. The Economics of Household Response to inadequate Water Supplies. In *Third World Planning Review* 16 (1): 41-53.

Altaf, Mir Anjum; Whittington, Dale; Jamal, Haroon und Smith, Kerry V. 1993. Rethinking Rural Water Supply Policy in Punjab, Pakistan. In *Water Resources Research* 29 (7): 1943-1954.

Andreini, M., N. van de Giesen, A. van Edig, M. Fosu, W. Andah. 2000. *Volta Basin Water Balance,* ZEF-Discussion Papers on Development Policy 21. Bonn: Center for Development, Research (ZEF).

Asante, F., Berger, T., Engel, S., and M. Iskandarani. 2002. Water security in the Ghanaian Volta Basin: Patterns, determinants, and consequences. In *Quarterly Journal of International Agriculture* (Special Issue on Agricultural water management and land use in relation to future water supply) 41(1/2) 145-167.

Brookshire, D. and D, Whittington. 1993. Water resources issues in the developing countries. In *Water Resources Research*, 29: 1883-1888.

Edig, A. van, Engel, S., and W. Laube. 2002. Ghana's water institutions in the process of reforms: From the international to the local level. In *Reforming institutions for sustainable water management,* ed. Neubert, S., W. Scheumann, and A. van Edig. Bonn German Development Institute (DIE).

Briscoe, J., P. Furtado de Castro, C. Griffin, J. North, and O. Olsen. 1990. Toward equitable and sustainable rural water supplies: A contingent valuation study in Brazil. In *The World Bank Economic Review* 4 (2): 115-134.

Community Water and Sanitation Agency. 2003. http://cwsa-gh.org/today/, 25.7.2003.

Granovetter, M. 1985. Economic Action and Social Structure: The Problem of Embeddedness. In *American Journal of Sociology* 91 (3): 481-510.

Ghana Statistical Service. 2000a. *Population and housing census*, Provisional Results.

Ghana Statistical Service. 2000b. *Poverty trends in Ghana in the 1990s*.

Ghana Statistical Service. 2002. *Population and housing census,* Summary Report of Final Results.

Howe and Dixon. 1993. Inefficiencies in water project design and operation in the Third World: An economic perspective. In *Water Resources Research* 29 (7): 1889-1894.

ISSER. 2003. *The state of the Ghanaian economy*, Legon: University of Ghana.

Lovei, L. and D. Whittington. 1993. Rent-extracting behavior by multiple agents in the provision of municipal water supply: a study of Jakarta, Indonesia. In *Water Resources Research* 29 (7): 1965-1974.

Madanat, S. and F. Humplick. 1993. A model of household choice of water supply systems in developing countries. In *Water Resource Research* 29 (5): 1353-1358.

Mensah, Kwadwo. 1998. Restructuring the delivery of clean water to rural communities in Ghana: the institutional and regulatory issues. In *Water Policy* (1): 383-395.

Merret, S. 2002. Behavioural studies of the domestic demand for water services in Africa. In *Water Policy* (4): 69-81.

Munasinghe, M. 1992. *Water supply and environmental management*. Chapter 1. Boulder, CO: Westview.

Mu, S., D. Whittington, and J. Briscoe. 1990. Modeling village water demand behavior: A discrete choice approach. In *Water Resources Research* 26 (4): 521-529.

Njoh, A. 2002. Barriers to community participation in development planning: lessons from the Mutengene (Cameroon) self-help water project. In *Community Development Journal* 37(3): 233-48.

Rogers, P., C. Hurst and N. Harshadeep. 1993. Water resources planning in a strategic context: linking the water sector to the national economy. In *Water Resources Research* 29 (7): 1895-1906.

Water and Sanitation Program – Africa Region (WSP-AF). 2002. *Rural water sector reform in Ghana: A major change in policy and structure*, Field Note 2 Nairobi, Kenya.

Weinberger, K. and J. Juetting. 2002. Women's participation in local organizations: conditions and constraints. In *World Development* 29 (8): 1391-1404.

Whittington, D., J. Briscoe, X. Mu, W. Barron. 1990. Estimating the willingness to pay for water services in developing countries: A case study of the use of contingent valuation surveys in Southern Haiti. *Economic Development and Cultural Change* 38 (2): 293-280.

Whittington, D., D. T. Lauria, and X. Mu. 1991. A study of water vending and willingness to pay for water in Onitsha, Nigeria. In *World Development* 19 (2/3): 179-198.

Whittington, D., S. K. Pattanayak, J-C. Yang, and K.C. Bal Kumar. 2002. Household demand for improved piped water services: Evidence from Kathmandu, Nepal. In *Water Policy* (4): 531-556.

WHO/UNICEF. 2000. *Global water supply and sanitation assessment 2000 report*. New York, Geneva: Joint Monitoring Programme for Water Supply and Sanitation (JMP).

World Bank Water Demand Research Team. 1993. The demand for water in rural areas: determinants and policy implications. In *The World Bank Research Observer*, 8 (1): 47-70.

World Bank. 1992. *Water supply and sanitation projects: The Bank's experience, 1967-1989*, Rep. 10789:137, Oper. Eval. Dep., Washington DC: The World Bank.

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